HIGHWAY DESIGN ORIENTATION TRAINING - ANSWERS

General Information - HDM Chapters 10 Thru 100

1. Freeway C.

   A divided arterial highway with full control of access and with grade separations at intersections.

   Expressway A.

   An arterial highway with at least partial control of access, which may or may not be divided or have grade separations at intersections.

   Conventional Highway B.

   A highway without control of access which may or may not be divided. Grade separations at intersections or access control may be used when justified at spot locations.

2. Overcrossing B

   Where a State Highway crosses under a Local Road.

   Undercrossing C

   Where a State Highway crosses over a Local Road.

   Separation A

   Where a State Highway crosses under another State Highway.

3. D. Both A and C

   For instructions on how to prepare a Design Exception Fact Sheet see Chapter 21 and Appendix BB of the Project Development Procedures Manual.

4. C. The HQ Project Development Coordinator.

5. A. Any standard given in the Highway jDesign Manual which is underlined and uses the word “should”.

   The procedures for preparing Advisory Design Exceptions vary for each district. See your district Design Chief for your district’s procedures.

6. B. The District Director.

7. D. All of the above!

8. D. The design speed is always equal to the posted speed.

Your answer is correct - this statement is NOT true. The anticipated posted speed should be considered when choosing a design speed, but they are not always the same. Typically the design speed is greater than or equal to the anticipated posted speed.

9. A. 50 - 70 km/h.

Given that the facility is a conventional highway and downtown Sacramento is an urban area with extensive development, Table 101.2 specifies a range of design speeds of 50 - 70 km/h.

10. B. Geometric design should be based on traffic estimated for the period 20 years after the completion of construction for NEW facilities and current ADT for RRR (Resurfacing, Restoration and Rehabilitation), safety and operational improvement projects.

11. D. FHWA approval of design standards is required for Interstate Completion projects or new or reconstruction projects on the Interstate System costing more than $1 million or where there is a change in access control.

12. C. All projects.

During the planning stage ALL projects are to be reviewed by the District Safety Review Committee prior to approval of the project initiation document.

13. D. All projects costing $300,000 or more OR which require a Traffic Control Plan.

Geometric Design Standards - HDM Chapter 200

1. D. L = 891 m.

Algebraic difference A=10%, and design speed V=100km/h.

2. B. L = 120 m

From Figure 201.5 you would calculate the minimum length of vertical curve to be 86 m but the minimum length of vertical curve based on a design speed of 60 km/h and an algebraic difference in grades of 2% and greater requires a minimum length of vertical curve of 2 times the design speed, therefore requiring a minimum vertical curve length of 120 m. Index 204.4, Figure 201.5, and Table 201.1.

3. D. L = 228 m

Index 201.3 increases stopping sight distance from Table 201.1 by 20%
190 x 1.2 = 228 m

4. A. L = 335 m

Index 201.7, 504.2, and Table 201.7

5. C. 120 m

Figure 202.5 gives runoff length for each curve = 90 m for e = 0.12 ("e" from Table 202.2) 2/3 of runoff is on tangent; therefore, (2/3) x 90 m x 2 = 120 m

6. B. 27 m

The superelevation rate for a 350 m radius curve on a frontage road with a design speed of 60 kmk/h is 4%. HDM Table 202.2(2). Since right of way is restrictive, the standard superelevation runoff length of 45 m is not appropriate. Use a rate of change of 4% per 20 m. HDM Index 202.5(3). Runoff length = 4% / 4% / 20 m = 20 m then 20 x 2 = 40 m for both curves. However, only 2/3 of the superelevation transition occurs on the tangent, so the minimum tangent length should be 2/3 of 40 m or 27 m. HDM Figure 202.5 & Index 202.5(2).

7. D. 6.34 m

Design speed for a 260 m radius curve is 80 km/h. HDM Table 203.2
Sight distance for 80 km/h is 130 m. HDM Figure 201.6
R = radius of center of the ramp lane = 260 m - (3.6 m/2) = 258.2 m
then from formula on figure 201.6 the lateral clearance = m and
m = 258.2 x [1 - cos (28.65 x 130 / 258.2)] = 8.14 m
subtract 1/2 width of lane to reach traveled way8.14 m - (3.6 m/2) = 6.34 m from traveled way to soundwall

NOTE: It would be prudent to consider the future need for a second ramp lane before locating the soundwall at the minimum distance from the edge of traveled way.

8. C. 0.3%

Indexes 204.3, 304.1, 304.2, & 306.1

9. B. -8 %

HDM Indexes 204.3 and 504.2(5)

10. A. 264 m

HDM Index 206.3

11. C. 75 km/h and over

HDM Index 209.1

12. A. 1.4 m

Vertical Clearance for falsework = 4.6 m HDM Index 204.6
7.0 m (grade difference) - 4.6 m (vertical clearance) - 2.4 m available for falsework depth and bridge deck thickness
then 2.4 m - 990 mm (miminum falseword depth Table 204.6) = 1.4 m

13. C. 1.5 m

HDM Index 208.1, 302.1, and Figure 208.1

14. D. 2.0 %

HDM Index 205.3

15. C. Approach railings

HDM Index 208.10

Geometric Cross Section - HDM Chapter 300

1. B. 2.4 m

HDM Index 307.2 and Table 307.2 states that Shoulder widths based on design year traffic volumes shall conform to the standards given in Table 307.2.

2. A. 1.2 m

HDM Index 307.3 and Table 307.3
Existing 6.6 m < 8.4 m Roadbed Min. therefore we widen to Roadbed Desirable Min. of 9.6 m; (9.6 m - (2x3.6)) / 2 = 1.2 m shoulders.

3. C. 5.6 m

HDM Index 309.2(2) and 309.2(1)(a)
5.1 m + 0.5 m = 5.6 m

4. C. 75.7 m

Your answer is correct.

Index 301.1 6 lanes @ 3.6 m	21.6 m
Index 305.1 Basic median width, rural	18.6 m
Table 302.1 Outside shoulder, one side	3.0 m
Index 304.1 Minimum catch point, one side	5.5 m
Index 304.2 Minimum clearance R/W to catch point	3.0 m
Index 310.2 Outer separation, freeway to frontage road	12.0 m
Figure 307.4 Freeway fence to R/W line	15.0 m
Figure 307.4 Freeway fence to frontage road traveled way	-3.0 m
	75.7 m

5. A. 0.6 m

HDM Index 302.1
6.6 m median - (2 x 3.0 m shoulder) = 0.6 m column
If the column required is greater than 0.6 m you would request a design exception from your Project Development Coordinator and FHWA. HDM Index 82.2.

6. C. 4.9 m

HDM Index 309.2
A digout will be required to maintain 4.9 m clearance.

7. B. 3.6 m & 2.4 m

HDM Index 305.1(2), 307.5, 108.3
Index 305.1(3) discusses the conditions where the standards may be reduced or eliminated entirely in extreme situations.

8. D. 20.1 m

When exit volumes are < 1500 but > 900, design should provide for a 2-lane (7.2 m) exit ramp in the future. HDM 504.3(5)

When a 2-lane exit ramp is required because of volume, a full (2.4 m) right shoulder must be provided at the nose because blockage in a lane with a reduced shoulder would not provide capacity for the exit volume and cause excessive queuing on the ramp and back onto the freeway. HDM 504.3(1)(c)

In light grading where normal slopes catch in a distance less that 5.5 m from the edge of the shoulder, a uniform catch point, at least 5.5 m from the edge of shoulder, should be used. HDM 304.1

When feasible, at least 5 m should be provided from the R/W line to catch point of a cut or fill slope. HDM 304.2

Therefore; 7.2 m + 2.4 m + 5.5 m + 5.0 m = 20.1 m

9. D. None of the above.

The correct answer is 3 m. See HDM Index 1102.2.

10. B. 3.6 m & 1.2 m

A local interchange means that the local facility has connections to the state facility. In these cases we require HDM cross section design standards on the local facility within the state R/W. If the locals have classified their facility (such as an arterial or collector road) we will reduce the outside shoulders to match the local standards for the approach roadway, but not less than 1.2 m.

If the local facility has no connections to the state facility, then we will allow local standards within state R/W, but not less than AASHTO standards.

11. A. 0.6 m

HDM Index 308.1 & Table 302.1

12. B. 1.2 m

HDM Index 308.1 & Table 302.1
Standard shoulder could be reduced to 0.6 m, but minimum horizontal clearance requires 1.2 m when shoulder is less that 1.2 m.

Intersections At Grade - HDM Chapter 400

1. C. 60 degrees.

A right angle (90 degrees) intersection provides the most favorable condition for drivers to judge the relative position and speed of approaching vehicles. However, a 60 degree angle generally does not unreasonably increase the crossing distance or generally decrease visibility. Crossroads skewed to the left should be avoided, because they cause restricted visibility for drivers of vans and trucks.

2. C. 230 m.

At the intersection of two State routes, the decision sight distance given in HDM Table 405.1B should be provided. For a design speed of 80 km/hr, the decision sight distance is 230 m.

3. C. 130 m.

The corner sight distance for a 60 km/hr design speed is 130 m.

At signalized intersections, the values for corner sight distance given in HDM Table 405.1A should be applied whenever possible. Even though traffic flows are designed to move at separate times, unanticipated vehicle conflicts can occur due to violation of signal, right turns on red, malfunction of the signal, or use of flashing red/yellow mode.

4. B. 30 m.

At unsignalized intersections, storage length may be based on the number of turning vehicles likely to arrive in an average 2-minute period during the peak hour.

2 min x 120 vph / 60 min per hr = 4 vehicles

Therefore, 120 vph is equivalent to 4 vehicles per 2-minute interval.
4 vehicles x 7.5 m/vehicle = 30 m

As a minimum, space for 2 passenger cars should be provided. If the peak hour truck traffic is 10% or more, space for one passenger car and one truck should be provided.

5. C. 150 m.

From the equation in HDM Figure 405.2B, L = (100)(100)(3.6)/150 = 240 m > 150 m. Therefore, the minimum length is 150 m.

6. C. 169 m.

It is desirable that deceleration take place entirely off the through traffic lanes, expecially when right of way is available for widening. According to HDM Table 405.2B, the length to stop is 169 m for a design speed of 100 km/hr.

7. A. 2.4 m.

For right turn lanes, the lane width shall be 3.6 m, and the shoulder width shall be 1.2 m. Therefore, 3.6 m + 1.2 m - 2.4 m = 2.4 m.

8. A. STAA truck template.

Because it has severe offtracking characteristics, the STAA Design Vehicle is the model for truck turn templates to be used on the National Network (which includes Interstates). The California Design Vehicle should be used on all routes off the National Network.

9. B. Flush paved areas outlined by pavement markings.

On facilities with speeds over 75 km/h, the use of any type of curb is discouraged. In rural areas, painted channelization supplemented with raised pavement markers would be more appropriate than a raised curbed channelization. The design is as forgiving as possible and decreases the consequence of a driver's failure to detect or recognize the curbed island

10. C. Two lanes.

With a single left turn lane, ILV/hr = 1400/2 + 275 + 600 = 1575. The ILV/hr greater than 1500 means that capacity is exceeded, therefore two left-turn lanes are warranted. For two lanes, ILV/hr = 1400/2 + 275 + 600/2 = 1275.

Traffic Interchanges - Chapter 500

1. D. 1.5 km in urban areas, and 3.0 km in rural areas.

The minimum spacing between interchanges shall be 1.5 km in urban areas, and 3.0 km in rural areas. The minimum spacing shall be 3.0 km between "freeway to freeway" and "local" interchanges.

The operation of a freeway is significantly effected by the location of interchanges, and adequate interchange spacing is required to avoid adverse impacts from merging and weaving. Strategies to improve the operations of closely spaced interchanges may include the use of auxiliary lanes, grade separated ramps, collector distributor roads, or ramp metering.

In addition to HDM Index 501.3, information regarding interchange spacing can be found in Design Information Bulletin Number 77.

2. B. 45 m to 60 m.

Radii for loop ramps should range from 45 m to 60 m.

Increasing the radii beyond 60 m is typically not cost effective, because the minimal increase in design speed is usually outweighed by the increased right of way requirements and the increased travel distance.

Curve radii of less than 35 m should also be avoided. Extremely tight curves lead to increased off-tracking by trucks and increase the potential for vehicles to enter with excessive speed.

3. C. R1 = 260 m and R2 = 100 m.

The design speed along the ramp will vary depending on alignment and controls at each end of the ramp. An acceptable approach is to set design speeds of 80 km/h and 40 km/h at the exit nose and ramp terminus, respectively. The appropriate design speed for any intermediate point on the ramp is then based on its location relative to those two points.

If the first curve is located just beyond the exit nose, a conservative approach would be to set the design speed at 80 km/h. Because the second curve is located prior to the ramp terminus, a design speed higher than 40 km/h is needed, and 50 km/h is typically used.

Therefore, for design speeds of 80 km/h and 50 km/h, HDM Table 203.2 show corresponding minimum radii of 260 m and 100 m.

4. A. 48 m.

The range of minimum deceleration length "DL" versus radius "R" is provided in a table on HDM Figure 504.2A. Given R = 250 m (between 151 m and 300 m), then DL = 130 m, and T = 130 m - 82.30 m = 48 m.

The minimum deceleration length shall be provided prior to the first curve beyond the exit nose to assure adequate distance for vehicles to decelerate before entering the curve. Because the deceleration takes place on the ramp, the freeway is allowed to operate at a more uniform speed.

Strong consideration should be given to lengthening the "DL" distance given in the table when the subsequent curve is a descending loop or hook ramp, or if the upstream condition is a sustained downgrade.

5. A. 160 m.

The preferred minimum distance between ramp intersections and local road intersections should be 160 m. The mandatory distance shall be 125 m.

Where intersections are closely spaced, traffic operations are often inhibited by short weave and storage lengths, and signal phasing. In addition, it is difficult to provide proper signing and delineation.

6. B. When design year volumes for the ramp exceed 1500 equivalent passenger cars per hour.

Where design year volumes exceed 1500 equivalent passenger cars per hour, a 2-lane ramp should be provided. An auxiliary lane approximately 400 m long should be provided in advance of a 2-lane exit. Provisions should be made for possible widening to three or more lanes at the crossroads intersection.

For volumes less than 1500 but more than 900, a one-lane width exit ramp should be provided initially, with provisions for the future addition of the second lane and the 400 m auxiliary lane.

7. D. Two-lane on-ramps should be discouraged.

By restricting the volume of entering vehicles, a single-lane on-ramp is less disruptive to the operation of the mainline freeway.

A two-lane entrance ramp, as shown in HDM Figure 504.3C, may be considered where design year volumes exceed 1500 vehicles per hour and adequate capacity exists on the through facility in the design year. However, the higher ramp volumes generally occur only in urban areas, where freeway capacity is limited. For most urban situations, it is recommended that multiple ramp lanes taper to a single lane prior to the 2-meter separation point (where merging is considered to begin).

8. B. 8.1 m.

According to HDM Table 504.3, a lane width of 4.5 m is required for a ramp radius of 60 m (between 55 m and 64 m). W = 4.5 m + 1.2 m (left shoulder) + 2.4 m (right shoulder) = 8.1 m.

Where ramps have curve radii of 90 m or less with a central angle greater than 60 degrees, the single ramp lane, or the lane furthest to the right if the ramp is multilane, shall be widened in accordance with HDM Table 504.3. The additional width is required to accommodate large truck wheel paths. Consideration may be given to widening more than one lane on a multilane ramp with short radius curves, if there is a likelihood of considerable bus or truck usage of that lane.

9. C. 71 m.

The width between bridge rails is 12 m, so it can be assumed that the crossroad consists of two 3.6 m lanes and two 2.4 m shoulders. From HDM Figure 504.3A,

a = 2.4 m
b = 1.8 m + 2.4 m + 3.0 m = 7.2 m
d = 170 m (based on a speed of 80 km/h)

Therefore, the ramp set back from the end of the bridge rail should be
c = 170 x [7.2 - (2.4 + 1.8)] / 7.2 = 71 m.

10. A. 130 m.

Vertical curves located just beyond the exit nose should be designed with a minimum 80 km/h stopping sight distance. According to HDM Table 201.1, a design speed of 80 km/h requires a stopping sight distance of 130 m.

11. C. To facilitate the development of superelevation.

It is important to develop the standard 2/3 full superelevation rate by the beginning of the curve, especially if the loop ramp is of a short radius and on a steep (over 6%) descent. The development of superelevation can be facilitated by beginning the ramp with a short tangent (20 m to 30 m) that diverges from the cross street at an angle of 4 to 9 degrees. Consideration should be given to developing additional tangent length if conditions allow.

12. C. 500 m.

The weaving volume is 500 + 700 = 1200 vehicles per hour. An approximation for adequate length of a weaving section is 0.3 m of length per weaving vehicle per hour. This rate will approximately provide a level of service C. Based on this criteria, 0.3 m x 1200 veh/hr = 360 m.

However, HDM Index 504.7 states that the weaving length should not be less than 500 m except where excessive cost or severe environmental constraints would require consideration of a shorter length. In addition, HDM Index 504.5 states that auxiliary lanes should be provided in all cases when the weaving distance is less than 600 m. Therefore, if the weaving distance between the interchanges is less than 600m, then the minimum length of auxiliary lane should be 500 m.

13. A. 0 m.

The acceleration lane begins at the inlet nose and ends at the point where the ramp is fully merged into the freeway mainline. The length of this lane is 330 m for all ramps, regardless of traffic volumes.

14. D. All of the above.

15. B. Partial cloverleaf (Type L-9).

The partial cloverleaf interchange is suitable for large turning movements. Left-turn movements from the crossroads are eliminated, thereby permitting two-phase operation at the ramp intersections when signalized. Because of this feature, the Type L-9 interchange usually has the capacity to handle the volume of traffic which can be accommodated on the crossroads.

Although the four-quadrant cloverleaf (Type L-10) has free-flow characteristics for all movements, the capacity of the interchange is limited by the short weaving section between the loop ramps.

16. D. At least 1 km from the nearest exit or inlet nose.

The basic number of mainline lanes should not be dropped through a local service interchange. The same standard should also be applied to freeway-to-freeway interchanges, unless more than 35% of the freeway traffic is turning.

Where the reduction in traffic volumes is sufficient to warrant a decrease in the basic number of lanes, the preferred location for the lane drop is beyond the influence of an interchange, preferably at least 1 km from the nearest exit or inlet nose. It is desirable to drop the right lane on tangent alignment with a straight or sag profile so vehicles can merge left with good visibility to the pavement markings in the merge area.

17. B. 700 m.

1200 m - 2(250 m) = 700 m.

18. B. 160 m.

19. D. All of the above.

20. A. 6%.

The maximum profile grade on freeway-to-freeway connections should not exceed 6%. Flatter grades and longer vertical curves than those used on ramps are needed to obtain increased stopping sight distance for higher design speeds.

21. D. The proposal is not acceptable.

The minimum spacing between a local interchange and a freeway-to-freeway interchange is 3.0 km, regardless of whether the area is urban or rural. However, compliance with the interchange spacing requirements involves meeting two criteria: minimum weaving length and minimum distance between centerlines of adjacent intersecting roadways. Even if the distance between centerlines is the standard 3.0 km, the weaving distance of 1200 m does not meet the minimum required weaving length of 1500 m.

22. C. Approval from Caltrans for all new interchanges is granted with the approval of a Project Study Report.

Caltrans approval of all new interchanges is granted with a Project Study Report, and the approval of nonstandard interchange spacing is granted with a design exception. Conceptual approval from FHWA is required only if the new interchange is located on the Interstate system.

23. D. Both A and B.

Although the proposal meets spacing requirements for an urban area, DIB 77 describes other conditions that must be satisfied before a proposal for freeway interchange revision or addition should be considered for approval. For example, interchanges should connect only to a public road and should provide all traffic movements. Isolated off-ramps encourage wrong-way accidents, because drivers expect to find return movements at the same location as exits.

Resurfacing, Restoration, and Rehabilitation (RRR) Projects

1. B. in the Geometric Design Criteria for RRR Projects - Design Information Bulletin-79 (DIB 79).

2. D Both B and C.

Not <u>all</u> of the RRR design criteria applies to rehabilitation projects on multi-lane conventional highways, expressways, and freeways. See Sections 1-200 and 4 of DIB 79.

3. B. 1.2 m.

4. A. 2.4 m.

5. C. 6.0 m.

Index 309.1 of the HDM states that the clear zone width should be increased depending on a number of conditions, including: traffic volumes, operating speeds, terrain, and costs.

6. C. 2-1/2%.

7. B. 8%.

8. A. generally may be left "as is" if there is not a related accident pattern. However approval of a mandatory design exception is required.

The requirement that superelevation shall be corrected on RRR projects was changed in DIB - 79.

9. B. 4.9m over all lanes and shoulders.

10. B. is low. The FHWA Region Office must obtain concurrence from FHWA Headquarters in Washinton D.C., who will coordinate all requests of this nature with the Military Traffic Management Command (MTMC) prior to approval.

This is part of the 42 000km Priority Network. The intention is to correct to standard vertical clearance on all major projects including RRR projects on this network. See Section 2 of Chapter 21 of the Project Development Procedures Manual.

11. D. Both B, and C.

Structural Section - HDM Chapter 600

1. D. All of the above.

   OGAC also is not recommended for use as a routine surface seal (See Index 608.2, page 600-31).

2. A. 105 mm of either asphalt treated permeable base (ATPB) or cement treated permeable base (CTPB).

   The standard thickness for the drainage layer in a PCCP structural section is 105 mm of either ATPB or CTPB, which allows the contractor the option to choose the most economical base. See Table 607.2, Footnote #3, page 600-23. For construction details, see Standard Plans D99 A, B, C and D.

3. D. Initial construction, maintenance and anticipated future pavement rehabilitation costs.

   See Index 609.3, page 600-44, for more information on pavement life-cycle costs.

4. B. Unless an exception is justified in the structural section submittal.

   Some potential reasons for an exception include a location with a very low mean annual rainfall (<125 mm) or where the basement soil is free draining (permeability > 0.000353 m/s). See Index 606.2 (3), page 600-17 for further details. For construction details, see Standard Plans D99 A, B, C and D

5. C. Greater than or equal to 10.

   Exceptions to this requirement are permitted under certain conditions, see Index 609.1, page 600-43.

6. B. Additional surface materials, grinding pavement surfaces and/or other related work needed to preserve the existing roadway.

   CAPM strategies are intended to preserve the existing roadway; not to upgrade the existing conditions, see Index 611.7, page 600-63. If it is necessary to upgrade the existing geometric features and appurtenances for safety purposes, a pavement rehabilitation project should be considered rather than a CAPM project.

7. C. The District Director, or their designee.

   Copies of the approval and other pertinent information (see Index 602.1, page 600-2 for details) must be sent to both Design and Local Programs - Office of State Pavement Design and Professional Engineer Development and the Engineering Service Center - Office of Materials Engineering and Testing Services (METS), Pavement Branch for their files.

8. D. Pavement design period.

The pavement service life (see Index 603.2, page 600-6) is the time period before major maintenance or rehabilitation is required and can be considerably longer or shorter than the design period due to weather extremes or higher than anticipated traffic loadings. The analysis period is the period used to perform an economic comparison, see Table 609.3, page 600-47. There is no such thing as a pavement traffic period.

9. D. A and B.

See Index 604.1, page 600-10, for further details.

10. B. The outer shoulder width should be increased to 3.6 m (lane width) and the structural section should be equal to the adjacent traveled way with the shoulder cross slope the same as the traveled way.

See Index 607.4, page 600-26 for additional information on concrete shoulders. Concrete shoulders are to be used for all PCCP new construction, however, AC shoulders may be used when justified and approved per Index 602.1 (3), page 600-2.

11. A. Roadside rests and Park and Ride lots.

Ramp structural sections are to be designed per Index 608.6, page 600-41. Structural sections for truck weight stations are to be designed based upon the project specific data (i.e. - climate, loadings anticipated, soil conditions, etc.).

12. C By a combination of functional areas.

Many units are responsible for the successful design and construction of bridge approach slabs. See Index 610.2, page 600-48 for details.

13. B. The Project Development Procedures Manual (PDPM).

The Project Development Procedures Manual (PDPM), also known as the "Gold Book" because of its binder color, completely describes the project development documents and procedures required to guide a project from initiation until completion. Part 2 of the PDPM describes the process and the Appendices include standard formats for the various documents required.

Highway Drainage Design - HDM Chapter 800

1. A. Detention / Retention Basin Design.

Among the other instances where district Hydraulic Unit support is necesary are backwater analysis, modifications or realignments of open channels, hydrograph development or routing, encroachments on FEMA designated floodplains and any other analysis where specialized hydraulic expertise is of benefit. See Topic 802 for more information.

2. C. The benefit/cost ratio of performing the upgrade is equal to or greater than one.

Where increases in storm water runoff are caused by development to upstream properties an assessment should be made of the costs and benefitsof upgrading the

State highway drainage facilities. If b/c ≥ 1, upgrading can be included in the project without external involvement. If b/c < 1, upgrading may still be pursued, but only if funding commitments are obtained from local agencies via the cooperative agreement process.

3. D. All of the above.

All of these situations require submission of information if the project is receiving federal aid. See Index 805.8 for an outline of the type of supportive information and number of copies to send.

4. B. The length of time for runoff to travel from the most remote point of the watershed to the point of interest.

The basic assumption of some hydrologic methods is, most notably the Rational method, is that maximum flow results when rainfall of uniform intensity falls over the entire watershed and the duration of that rainfall is equal to the time of concentration. This type of method provides reasonable accuracy only for relatively small watershed areas. See Topic 816 for additional information.

5. D. The peak discharge flood event associated with the probability of exceedance selected for the highway encroachment.

The design flood is selected so that an appropriate balance is struck between the risks and costs associated with flooding of the highway facility and/or adjacent properties. Generally, the design period will be selected to assure that the highway is not inundated by the design event.

The “design storm” may or may not produce the “design flood”, depending upon antecedant moisture conditions, possible snowmelt, and other factors. See Topic 818 for additional information.

6. C. 1500 mm.

For safety, aesthetics and economics flared end sections should typically be used at both entrances and outlets whenever feasible instead of headwalls. See Topic 826 for additional information.

7. C. 600 mm.

Although the intermediate cleanout access would allow the 450 mm culvert to meet the minimum criteria, it is preferable to install the 600 mm culvert. Remember, this only establishes the <u>minimum</u> diameter. Final determination of culvert diameter will still be dependant upon passing the design flow and associated debris.

8. D. 50-yr. storm, water spread to 1/2 of outside lane.

Had the location in question been “on-grade”, the correct answer would have been C. However, for freeways and conventional highways in sag locations that require pumping, the design storm should be the 50 year event. Refer to Topic 831 and Table 831.3.

9. D. 100 mm Type F.

Type C low dike is the only type of dike that may be placed in front of MBGR and Type F is to be placed directly under the face of MBGR. For rehabilitation projects where the existing dike under the face of MBGR is Type A, eithe the dike must be removed and replaced with type F, or more commonmly, the MBGR must be stiffened to limit deflection (ususally by attaching a rail element along theback side of the MBGR posts).

10. B. 25 years or 50 years.

For roadbeds less than 8.4 m in width, the minimum design service life for all culvert materials (RCP, CSP, PPC, etc.) is 25 years if the cover over the pipe is less than 3 m and 50 years if the cover over the pipe is 3 m or greater. If the roadbed is an interim alignment, the minimum design service life is 25 years.

11. C. Soiltight Joint with filter fabric wrap.

This pipe will occasionally flow full, the surrounding soil has a high potential for migration, there is no groundwater contact, and some infiltration and/or exfiltration is acceptable. Refer to Topic 853 and table 853.1C

12. B. RCP, 4.27 mm CSP, 1.63 mm CASP, PPC, 2.67 mm CAP

RCP will work for the given conditions, NRCP will not as it should not be placed under the roadbed. By referring to Figure 854.3B we see that the minimum CSP thickness that can be used is 4.3 mm to withstand the corrosive conditions. 1.63 mm CASP and 1.52 mm CAP are adequate to resist corrosion. However, from Tables 854.4 A and 854.4 B we see that the minimum available thickness of CAP in the 1200 mm diameter is 2.67 mm. CASP has the same load carrying strength as CSP. By referring to Tables 854.3 B and C it is apparent that the 1.63 mm thickness is adequate to carry the soil load. PPC can be either high density polyethylene (HDPE) or polyvinyl chloride (PVC). Table 854.8 shows that although 1200 mm HDPE will not be acceptable, 1200 mm PVC will be. Therefore, PPC can be listed.

13. B. 2.4 m/s

Contolling the slope and discharge so that velocities do not exceed the values indicated in Table 862.2 will limit the possibility of scour and erosion in unlined channels.

14. B. Gabion mattresses, vegetation & riprap.

Please refer to Topic 872 and Table 872.1 for a listing of the various types of bank protection and where they are applicable.

15. D. All of the above.

Designers should coordinate with the distict Landscape Architecture Unit so that storm water facilities blend in to their surroundisgs as much as possible.

Maintenance access is a must, as is early discussion with maintenance staff to alert them that a feature that will require on-going maintenace is being installed. Any information on how often maintenance will be required or on any special equipment or material needs must also be passed on to Maintenance staff.

Few water quality facilities can accept the discharge volumes associated with the highway facility design storm. Most can accomodate discharges on the order of the first 12 mm of runoff. Greater flow levels should be designed to bypass the facility to avoid possible backwater development, harm to the water quality facility, or resuspention of detained sediments. Refer to Topic 892 for additional information.

16. A. 900 mm HDPE solid wall pipe (SDR 26) and 900 mm PVC closed profile wall pipe.

The 1000 mm maximum outside diameter limits the PVC Ribbbed pipe and Type S HDPE to 750 mm inside diameters, below the 840 mm needed dimension. 900 mm PVC closed profile wall pipe will work (899 mm internal dimension and 960 mm external) and has a stiffness of 320 kPa, which is a plus as it will be quite resistive to the pressure exerted during the annular space grouting operation. Two sizes of HDPE solid wall pipe in the 900 mm dimension will work, SDR 32.5 (858 mm internal dimension and 914 external) and SDR 26 (844 internal dimension and 914 external). SDR 32.5 should typically only be used if it is the only wall thickness that will fit as its relatively low stiffness is more susceptable to deformation during grouting. See Design Information Bulletin #76 for more information on plastic pipe reliners.

Landscape Architecture - HDM Chapter 900

1. D. Design and Local Program (Office of State Landscape Architecture)

2. D. All of the above.

3. A. Sight distance and Safety (clear recovery zone)

4. A. 9 meter

5. D. Providing median planting

6. C. Both A & B

If retaining walls or sound barriers are located within the clear recovery zone (see Index 902.2), plants may be placed behind the walls and be allowed to grow over (or through) the wall, or plants may be placed in front of the wall, but they must be behind a concrete safety shaped barrier.

7. B. When bridge is in low ADT traffic area

However, an exception must be granted from Bridge Maintenance.

8. C. Project Development Coordinator and Geometric Reviewer of HQ Design and Local Programs

9. A. Facility for motorist may stop for a short period to rest and relax

10. D. All of the above

11. C. District Landscape Architect

12. B. Standard freeway exit and entrance ramps

Bikeway Design - HDM Chapter 1000

1. Class I Bikeway (Bike Path) B

   Provides a completely separated right of way for the exclusive use of bicycles and pedestrians with crossflow minimized.

   Class II Bikeway (Bike Lane) C

   Provides a striped lane for one-way bike travel on a street or highway.

   Class III Bikeway (Bike Route) A

   Provides for shared use with pedestrians or motor vehicle traffic.

2. D. All projects regardless of the ownership or funding.

   Per the Streets and Highways Code Local Agencies must comply with Chapter 1000 of the Highway Design Manual. Note: The pertinent sections of the Streets and Highways Code are summarized in the HDM Index 1001.2.

3. B. When determining pavement widths, bicycles only need to be considered on roadways with designated bikeways.

   Your answer is correct - this is a FALSE statement. The needs of bicyclists should be considered for all project types.

   It is important to note that whenever a roadway is resurfaced the entire paved shoulder and traveled way must be resurfaced. This is true regardless of the project size (major or minor projects) and is also true for CapM projects.

4. B. 3.6 m.

   The minimum paved and graded width combined is 3.6 m. The minimum paved width is 2.4 m with 0.6 m graded area adjacent to both sides.

5. D. None of the above.

   Per Index 1003.1(5), a barrier is required when the path is 1.5 m or closer to the edge of shoulder OR if the path is located within a freeway clear recovery zone.

6. B. 1.5 m.

7. D. Bicycles are permitted on freeways in some instances when approved by the Headquarters Traffic Reviewer and Coordinator.

Ramp Meter Design

1. D. B or C, depending on whether a HOV bypass is provided, the amount of storage available and the percent of HOV's.

2. C. A 300 m auxiliary lane should be provided.

3. A. 50:1.

4. C. The ramp should be tapered to a single lane by the convergence point.

5. B. 30:1

   This taper "matches" the design speed.

6. C. The right and left shoulder width may be 0.6 m.

7. D. A and C.

8. D. A and B.

9. D. 9 m.

10. A. A 300 m long auxiliary lane, should be provided beyond the convergence point.

High Occupancy Vehicle Facility Design

1. B. Only after every effort to conform to the HDM is unsuccessful.

   Justification for the use of anything less than "preferred" geometrics must be well documented by a sound engineering analysis and a design exception approved by the Project Development Coordinator. Refer to Topic 82, Chapter 80 of the HDM.

2. D. all of the above

3. B. 6.3 m

   Although the preferred width is 7.8 m, the minimum width ensures that a stalled bus will not block the HOV lane. Reduction of this width, even at local obstructions, should be avoided unless absolutely necessary.

4. A. 7.8 m

   The 7.8 m width between barriers provides flexibility for future conversion to two 3.3 m lanes with 0.6 m shoulders.

5. B. 7.2 m

   (1.2 m inside shoulder) + (3.6 m lane) + (2.4 m outside shoulder) = 7.2 m

6. D. 1.2 m

A 13.8 m median would provide 6.6 m on each side after subtracting the width of the median barrier (13.8 m - 0.6 m) / 2 = 6.6 m. Since the preferred geometrics would require 8.7 m, a compromise will be required and the suggested priorities in Section 3.10 of the HOV Guidelines should be followed.
(2.4 m median shoulder) + (3.3 m HOV lane) + (1.2 m buffer) - (0.3 m from mixed flow lane #1) = 6.6 m

7. C. 1.2 m

A 9 m median would provide 4.2 m on each side after subtracting the width of the median barrier (9 m - 0.6 m) / 2 = 4.2 m. Since the preferred geometrics would require 7.5 m, a compromise will be required and the suggested priorities in Section 3.10 of the HOV Guidelines should be followed. Since the outside mixed-flow lane should remain at 3.6 m because of trucks, the median shoulder should be reduced to 1.2 m in the fourth step. (1.2 m median shoulder) + (3.3 m HOV lane) - (0.3 m from mixed flow lane #1) = 4.2 m

8. B. 20 : 1

A vertical face concrete barrier should be used between bridge columns in the median.

9. C. Continuous paved median 4.2 m or wider in both directions.

CHP enforcement is a necessary element for the successful operation of an HOV system. If right of way is unavailable for a continuous 4.2 m paved median shoulder, then directional or bi-directional enforcement areas should be provided. These areas should be typically 400 m in length and spaced 3 km to 5 km apart. Deviation from these typical configurations could lead to a perception of unsafe conditions by the CHP officer and result in non-use.